U.S. Coast and Geodetic Survey
The neglected waters of the Pacific coast

DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

E. LESTER JONES, SUPERINTENDENT

THE NEGLECTED WATERS OF THE PACIFIC COAST

WASHINGTON, OREGON, AND CALIFORNIA

By

E. LESTER JONES

SUPERINTENDENT

Special Publication No. 48

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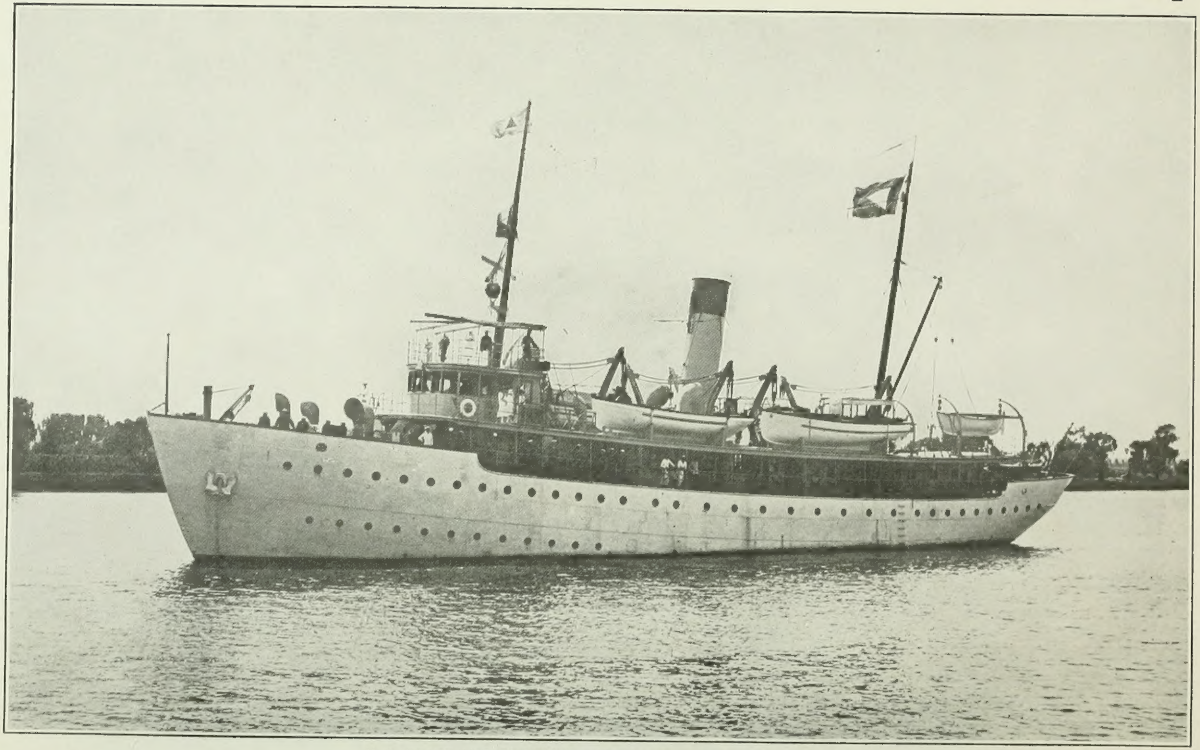

U. S. COAST AND GEODETIC SURVEY STEAMER "SURVEYOR."

The most modern surveying vessel, designed especially for work on the Pacific coast. Now temporarily in the United States naval service.

THE NEGLECTED WATERS OF THE PACIFIC COAST:

WASHINGTON, OREGON, AND CALIFORNIA.

HISTORICAL.

Washington, Oregon, and California became part of continental United States in 1848, or 70 years ago. Few people in our vast country know of conditions that exist on the Pacific coast, and the very dissimilar conditions and character of the shore line as compared with the Atlantic coast. For example, the Atlantic coast line is largely of mud and sand formation with comparatively little elevation, while the Pacific coast of Washington, Oregon, and California can almost be said to be entirely rocky and precipitous.

In addition to this, the Atlantic and Gulf coasts have many harbors scattered from Maine to Texas—excellent harbors where vessels may seek refuge in time of storm. Quite the opposite condition exists on the Pacific coast, where there are very few harbors and these widely scattered. After leaving the Strait of Juan de Fuca, the northern boundary of Washington, the next point of refuge is Grays Harbor, a distance of nearly 100 miles, and after that Willapa Bay and the Columbia River, the last named separating Washington and Oregon. And so on down the coast, it will be readily understood by the accompanying illustrations that many miles are traversed without the possibility of making a safe landing either by a harbor or by a sheltered sand or mud beach. Moreover, the prevailing heavy swell makes landing difficult and dangerous, even under the best conditions that are found there.

The above unchangeable conditions, together with the primary importance to our country of the commerce of its Pacific coast, furnish unanswerable arguments why the neglected Pacific coast waters should be well surveyed without further delay, and otherwise protected for the perpetual safeguarding of human beings, the vessels they travel on, the Navy, and property in general.

The following explanations and illustrations are set forth with the endeavor of clearly showing in the most practical manner the real conditions that exist to-day and the remedy.

CHAPTER I.—INTRODUCTORY.

GENERAL DESCRIPTION OF PACIFIC COAST.

The Pacific coast of the United States is in general rugged and mountainous, the high land in many places rising abruptly from the sea. The shore is generally bold and rocky, with occasional short stretches of narrow sand beach. Southern California has a number of beaches and along the Oregon and Washington coasts sand beaches front the shallow lagoons and bays, but the entire coast is backed by the coast range, which frequently terminates at the shore in high cliffs and jagged off-lying rocks. (See fig. 2.)

The hydrographic characteristics form a parallel to the topographic features above mentioned. Generally, deep water extends close to the shore and outlying rocks, and the 100-fathom (or 600-foot) curve of depth lies but a few miles from the shore in most places. Similar to the gorges in the mountains, deep submarine valleys frequently occur off the coast, some of them reaching almost to the shore.

METEOROLOGICAL CONDITIONS.

WEATHER.—There are two seasons—the summer or dry season, which begins about May and continues until October, and the winter or rainy season, covering the remainder of the year. These seasons vary in length in different parts of the coast as well as in different years.

Along the southern part of the coast the rainy season is comparatively short and the rainfall much lighter than in the northern portion, being so light in some years as to cause considerable damage to stock and farming industries. The winter gales from southward and southwestward are less frequent and less severe than at more northern points. The temperatures are milder and more even and the snowfall is limited to the higher mountain peaks.

Northward of San Francisco the rainy season increases in length and amount of rainfall, and as Juan de Fuca is approached showers of short duration and generally local may be looked for at any time. On rare occasions snow falls in San Francisco and vicinity, but is frequent and at times heavy in the vicinity of Juan de Fuca Strait. From San Francisco northward the winter gales increase in severity, frequency, and duration, while in summer the northerly and northwesterly winds at times reach almost hurricane strength.

WINDS.—The prevailing winds in summer are from northwest and west, on the northern part of the coast; on the southern part, from west and southwest. The northwest winds in summer frequently reach a velocity of 70 miles an hour and extend as far south as Point Conception, eastward of which their severity is much less. As a rule, the northwest wind begins about sunrise and reaches its maximum velocity about 3 or 4 p. m., moderating toward sunset and dropping to light airs or calms by daylight. The severe northwesterly gales generally last two to three days and continue throughout the night with little or no diminution.

In winter the heaviest weather is from southeast and southwest, with an occasional northerly gale of short duration. The southeast gales occur at any time, generally accompanied by rain and thick weather and increasing in severity northward. These gales, with the heavy southwest swell prevailing during the winter months, cause a confused, irregular sea that taxes the weather qualities of a vessel to the utmost.

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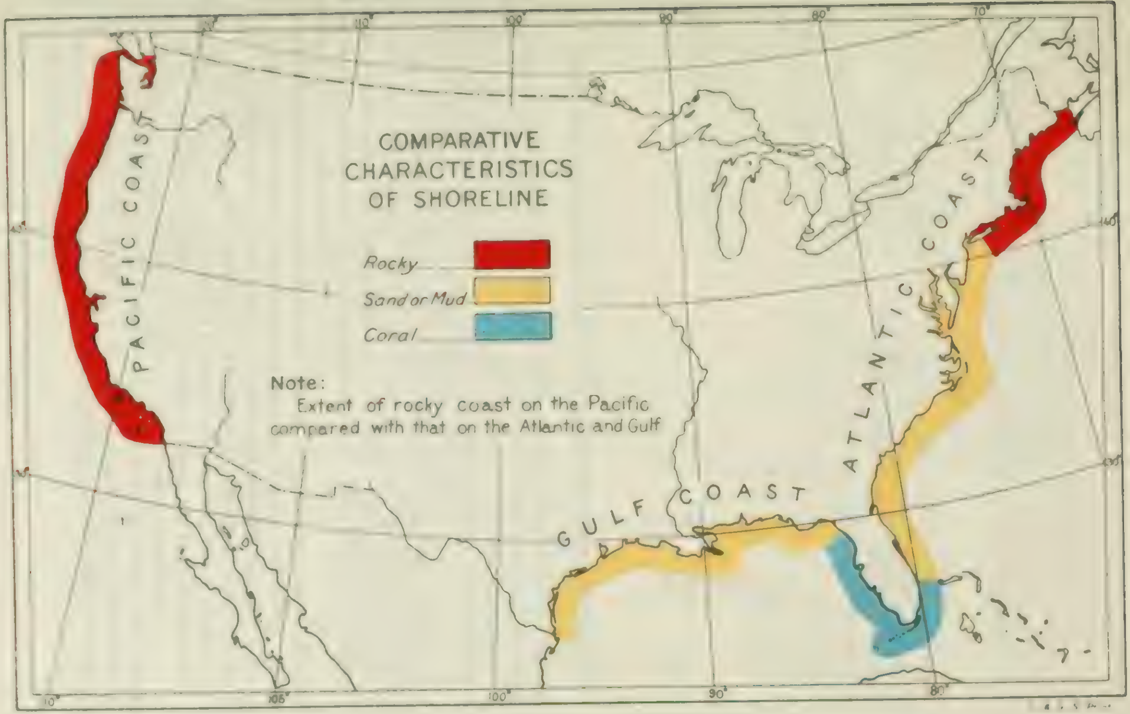

COMPARATIVE
CHARACTERISTICS
OF SHORELINE
Rocky
Sand or Mud
Coral
Note:
Extent of rocky coast on the Pacific
compared with that on the Atlantic and Gulf
PACIFIC COAST
ATLANTIC COAST
GULF COAST

FOG.—On the outside coast fogs are liable to occur at any time, but are more frequent in July, August, and September. On the southern part of the coast they are light and generally clear away by noon. In the northern parts of the coast they are more frequent and at times are very dense, and have been known to extend several hundred miles seaward. They continue at times for weeks, rendering navigation difficult, and frequently require considerable wind to dispel them. They are generally brought in toward sundown, from seaward, by light westerly winds, and ordinarily continue until noon of the following day, and sometimes later.

PACIFIC COAST WEATHER

Locality	Mean temperature January.	Mean temperature July.	Average annual precipitation.	Number days per year rain or snow.	Maximum wind velocity.	Number days per year dense fog.	Fog signal operated per year.
	°F.	°F.	*Inches.*		*Miles.*		*Hours.*
San Diego, Cal.	54	67	10	42	45	24	261
San Francisco, Cal.	49	57	22	68	64	28	516
Point Reyes, Cal.	49	54	25	70	120	148	1,316
Eureka, Cal.	47	55	46	125	59	65	
Columbia River entrance, Wash. and Oreg.	42	58	40	196	96	44	634
Tatoosh Island, Wash.	41	55	89	205	90	60	722
Neah Bay, Wash.	41	58	109	204	60	11	
Seattle, Wash.	39	64	37	165	64	36	344

HARBORS ON THE PACIFIC COAST OF THE UNITED STATES.

The Pacific coast of the United States, having a total length of about 1,100 nautical miles from the Mexican boundary to the Strait of Juan de Fuca, has comparatively few harbors of refuge or entrances from sea which are available for vessels in heavy weather.

San Diego, a harbor of refuge, is about 10 miles northwestward from the Mexican boundary and Los Angeles Harbor is 90 miles northwestward of San Diego.

There is no real harbor between Los Angeles and San Francisco, a distance of 367 miles, although there are open roadsteads at Santa Barbara, 87 miles north of Los Angeles; at San Luis Obispo, 80 miles north of Santa Barbara; and at Monterey Bay, 120 miles north of San Luis Obispo and 80 miles south of San Francisco entrance. San Francisco is one of the important harbors on the Pacific coast.

Between San Francisco and the Strait of Juan de Fuca, a distance of 663 nautical miles, there are five bar harbors which may be safely used by Coast and Geodetic Survey vessels as harbors of refuge while surveying the coast. These are Humboldt Bay, 221 miles north of San Francisco; Coos Bay, 155 miles north of Humboldt Bay; Columbia River, 170 miles north of Coos Bay; Willapa Bay, 25 miles north of Columbia River; and Grays Harbor, 15 miles north of Willapa Bay. From Grays Harbor to the Strait of Juan de Fuca is 95 miles. The Strait of Juan de Fuca is an entrance from sea which is always open to vessels.

Between San Francisco and the Strait of Juan de Fuca there are also harbors with bars at Coquille River, Umpqua River, Siuslaw River, Yaquina Bay, and Tillamook Bay which are available for vessels of the Coast and Geodetic Survey under favorable conditions of tide and weather when the bar is not breaking.

HISTORY OF SURVEYS.

California was discovered by the Spaniards in the course of their search for a strait between the Atlantic and Pacific Oceans. The coast was explored by Cabrillo and Ferrelo in 1542 and 1543 as far north as Punta Arena. The multiplicity of Spanish names in this region is due to their explorations. In 1579 Drake, the English adventurer, explored the coast northward to the vicinity of Cape Blanco, Oreg. The Spaniards continued explorations until 1603, after which there was little done until 1767, when they resumed explorations. Vancouver partially explored the region on a trip along the California coast in 1793. The Russians coming down from the north between 1803 and 1806 penetrated south of the Strait of Juan de Fuca in their search for sea otter. Various expeditions added to the crude maps and charts of the coast until the discovery of gold in California in 1848, which resulted in a tremendous increase in the number of ships navigating these waters, calling for more accurate surveys.

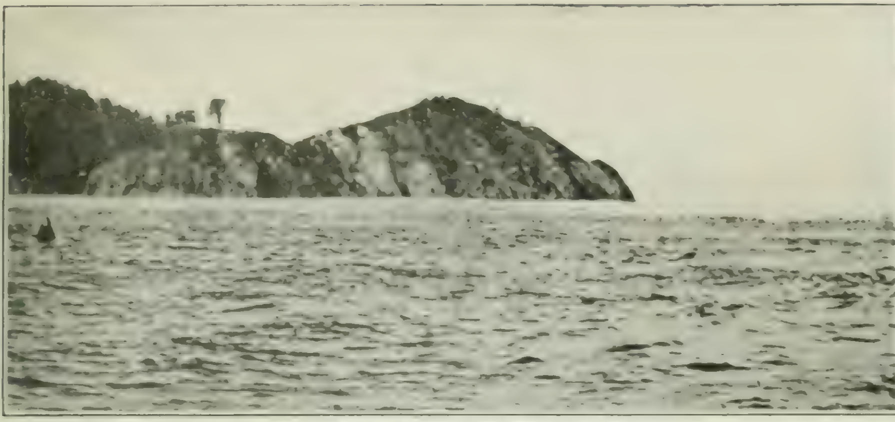
The Coast Survey began surveying this region in 1850 and continued without interruption until 1895, since when but little work has been done on the exposed portions of California, Oregon, and Washington.

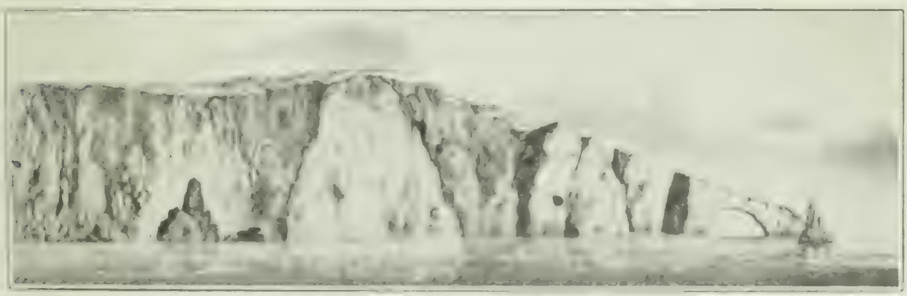
The early explorations were accompanied by the usual hazards of the pioneer; shipwreck and hunger, after battling with the elements, were frequent. The Coast Survey did not escape the mishaps common in unsettled regions, for, during the California gold rush, the crew of one of its vessels, eager for the excitement and gold, mutined, killing several officers and deserted. The Indians were hostile and hampered the progress of the work in places; neither did the Survey's officers and men escape the always present dangers of landing on an exposed coast. (See fig. 3.)

Subassistant Julius Kincheloe, who entered the Coast Survey in 1854, was drowned with five of the crew of six by the capsizing of the whaleboat in the breakers at the entrance to Tillamook Bay, Oreg. The survey of the bay had been completed, and on May 20, 1867, while attempting to obtain soundings on the bar, a breaker rising suddenly capsized the boat.

Lieutenant F. H. Crosby, United States Navy, one quartermaster, and three seamen were drowned in the surf north of Grays Harbor entrance, Washington (about 17 miles north of entrance), while trying to effect a landing through the surf to build a signal, August 18, 1894. Of the nine men in the boat with him five reached the shore in safety. It was supposed that the sudden shutting down of a dense fog prevented them from seeing the breakers as they rolled in and capsized the boat.

The early surveys by the Coast Survey were made principally from sailing vessels. The difficulty of taking deep soundings from such vessels and the uncertainty of their motive force made the task a slow and laborious one, and, in addition, introduced some unavoidable errors in the soundings. These errors made little difference to the slow-going, shallow-draft vessels of those early days, but become important in these modern times of fast steamers, operating on exacting schedules; and as a result partly of these inaccuracies and partly of the entire lack of surveys in certain localities additional work is urgently needed. (See fig. 4.)



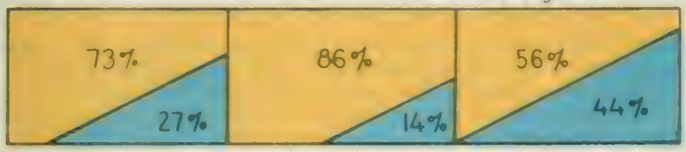


Condition of water surveys, Pacific Coast, 1918, as compared to the Philippine Islands

United States Coast and Geodetic Survey

California Oregon Washington

Part of continental U. S. since 1848 (70 years)



Orange (73%, 86% and 56%) - represents unsurveyed water areas.

Blue (27%, 14%, and 44%) - represents water areas surveyed in past 68 years.

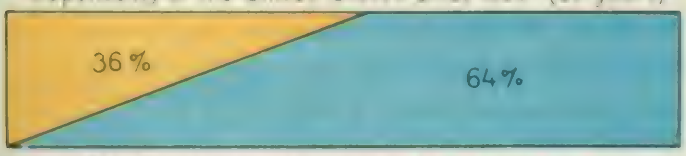
One vessel of the Surveyor type will require 20 years to complete a first survey of the navigable waters of this coast.

For 21 years no systematic survey of water areas has been made on account of lack of vessels.

Now compare work done in the

Philippine Islands

Dependency of the United States since 1898 (20 years)



Orange (36%) - represents unsurveyed water areas

Blue (64%) - represents water areas surveyed in past 18 years

Philippine surveys have progressed more rapidly in 18 years than in the other regions shown on this sheet due to the funds and four (4) ships supplied by the Philippine Government.

CHAPTER II.—PREVAILING CONDITIONS.

REASONS FOR IMMEDIATE SURVEYS.

In order to fully appreciate the need of detailed and accurate surveys on the Pacific coast one must realize the conditions under which its navigation is accomplished.

The first of these conditions is the configuration of the coast line. The entire coast from the Strait of Juan de Fuca to San Diego falls, roughly, into a series of arcs of circles between adjacent projecting points. Between the Strait of Juan de Fuca and San Francisco Bay, for example, there are four such arcs—between Cape Flattery and Cape Blanco, Cape Blanco and Cape Mendocino, Cape Mendocino and Point Arena, and Point Arena and Point Reyes.

The usual steamer track, which is a straight line between adjacent points, forms a chord of these arcs, and thus it follows that the steamer gradually recedes from shore after passing a point, and then approaches the shore again as it nears the next point.

The second condition is thick weather, either the fog of the summer months or the rain or snow which accompanies the winter gales. Because of this thick weather it is frequently impossible to determine a vessel's position by the ordinary methods of coastwise navigation, which consist of referring it to known objects on shore. It is by no means uncommon for a vessel to be compelled to make the entire run from the Strait of Juan de Fuca or the Columbia River to San Francisco without obtaining a sight of land.

The third condition is currents. There may be some localities in the world where, if point B is 100 miles south of point A, the navigator, knowing that the speed of his vessel is 10 miles per hour, can steer south from A through fog for 10 hours and feel certain that his vessel is off point B. But the Pacific coast is not one of them. If the navigator tries that method here, at the end of 10 hours he may be anywhere from 80 to 120 miles south of point A, and from 4 to 8 miles on either side of his intended track. In other words, the chances are about even that he will be ashore.

CURRENTS ON THE PACIFIC COAST OF THE UNITED STATES.

This problem of the currents on the Pacific coast is one of the most difficult with which mariners anywhere are compelled to contend.

The movements of these waters have neither the comparatively uniform direction and velocity of the Gulf Stream nor the constant ebb and flow of the tidal currents. They appear to be surface currents mainly, caused by the prevailing meteorological conditions, and as such to be subject to frequent change in both direction and velocity. They may be flowing north this week and south next week, or they may die out entirely.

Professor George Davidson, for many years an officer of the Coast and Geodetic Survey, and later professor of geography in the University of California, spent many years engaged on hydrographic and geodetic surveys on the Pacific coast, during which time he devoted a great deal of study to the subject of coastwise currents. As a result of such study, Professor Davidson concluded that there existed, from 50 to 100 miles offshore, a southerly setting current of unknown width and velocity, and that inside of this, following closely along the general trend of the coast, was a northerly setting current which he named the "Davidson Inshore Eddy Current."

The data on which Professor Davidson's conclusions were based were necessarily meager. He had observed such northerly setting currents at various anchorages while engaged on survey work along the coast, and had also ascertained that logs of the redwood (which does not grow north of California) were frequently found on the shores of Washington, British Columbia, and even Alaska, the wood being well known to the natives of these regions. Obviously, the only way such logs could have reached these shores was by being carried there by the currents.

Professor Davidson was too good a scientist to attempt to promulgate a theory more definite than was justified by the available data, and there is, so far as known, nothing to indicate that in naming this current he had in mind anything more than a general tendency to a current flowing in a northerly direction, which tendency might at any time disappear or be reversed by the prevailing weather conditions.

Certainly, such additional facts as have been gathered since that time do not indicate anything which might be described as a decided permanent set in any direction. As already stated, these currents, from the practical viewpoint of the navigator, appear to be the result of the prevailing weather conditions. As a general rule, to which, however, there are many exceptions, it appears that in the summer months when the winds are northwesterly, the tendency of the current is toward a southerly set, and in the winter, when the winds are southeasterly to southwesterly, the currents will in general be northerly.

The data available at present do not permit of formulating any definite theories regarding the origin and occurrence of these currents, but certain characteristics have been noted which it is important that the navigator should have in mind, as they may materially assist him in avoiding disaster.

RELATION OF CURRENTS TO STRANDINGS AND WRECKS.

An inquiry into this subject of currents and their relation to navigation, including interviews with navigators and a study of the investigations made by the Steamboat-Inspection Service into the causes of strandings, indicate the following:

1. As a preliminary it may be stated that the currents are frequently blamed for disasters for which they probably are in no way responsible. In a large percentage of the above strandings total lack of knowledge of the compass deviation was the most striking fact brought out in the investigation. The course was shaped from the log of some previous voyage, and no one knew what the corresponding magnetic course might then be. The factors which cause deviation from the track are changing and uncertain. On no two voyages are they identical. Wherefore, to rely blindly on a course merely because it was made good on some previous occasion is to invite certain ultimate disaster.

2. Although a knowledge of the compass error is essential, in thick weather the navigator should never rely on that instrument alone. There are undoubtedly many periods when the currents are not in operation, and the magnetic course steered will be made good. But there is no way of telling when such periods occur. As a rule navigators can not count on making their courses and distances good, or assume that even though such courses lead, in general, from 6 to 10 miles off the nearest shores they have allowed an ample margin of safety. It is by no means uncommon for vessels to be set 10 or 12 miles off their courses in as many hours, and to have their speed made good, accelerated, or retarded by considerably greater amounts.

3. The majority of strandings have occurred in foggy but comparatively calm weather. Various reasons may be advanced in explanation of this fact, one of them undoubtedly being the failure of the navigator to realize that currents of considerable velocity are frequently encountered when there are no other unfavorable local conditions to warn him of their existence.

4. The commonly accepted rule among navigators regarding the currents is that they follow the prevailing winds, setting, in general, southward in summer and northward in winter. This rule appears reliable for times when the local winds attain any great velocity, but it is not safe to accept it for periods of calm or light airs. The records of strandings under the latter conditions show numerous cases which were undoubtedly caused by northerly currents in summer or southerly ones in winter. In short, the currents are subject to variation, not only from season to season but from day to day.

5. In the majority of the cases where the strandings appear to have been directly due to currents, the currents have been against the vessel. Most of the strandings have happened to deeply laden, southbound vessels to the northward of the projecting points like Blanco, Mendocino, and Arena.

PRESENT UNCERTAIN KNOWLEDGE RELATIVE TO CURRENTS.

The consensus of opinion among the navigators of the coast is that the currents follow the curve of the shore. If this is true, a vessel southbound against a northerly current would experience a tendency to set in to the northward of the points and out to the southward of them. As a specific instance, one navigator states "If you have seen Cape Blanco and Northwest Seal Rocks and find you have been set off a little and the speed made good retarded some, then you can be sure you will be set in toward Cape Mendocino, or if you have set in toward Seal Rock and your speed has been accelerated, then you can be sure you will be set off on nearing Mendocino." The general configuration of the coast tends to support this theory. As already stated, wrecks to southbound vessels occur to the northward of Blanco, Mendocino, and Arena. More southbound vessels have been lost in the vicinity of Punta Gorda than at any other point along the coast. It is in these localities that the deviation of the coast from its general north and south direction is greatest.

There is one serious objection to the theory that the currents follow the curve of the shore. It can readily be seen how a current flowing in a general north or south direction would be deflected to the westward by the points projecting in that direction, resulting in a tendency to set the vessel offshore; a set experienced as she approached the point if traveling with the current, or after passing it if the current was against her. But it is difficult to conceive of any agency which could redeflect that current to the eastward after it had passed a point which had already caused it to swing off to the west.

Theoretically, it seems more reasonable to suppose that the phenomena which have been observed are caused by currents which originated well offshore and flowing in strike the coast and are deflected to the north or south. This theory would explain the fact, already noted, that currents are so frequently encountered in relatively calm weather. It would also explain the fact that vessels have frequently experienced a considerable set directly inshore caused by currents acting so squarely across the track that they had no effect on the distance made good. Sets of this character appear to be particularly frequent between Heceta Bank and Cape Arago, between Trinidad and Cape Mendocino, and off Monterey Bay.

Thus it appears that from our present knowledge of the currents the most accurate statement which we can make regarding them is that we know they are uncertain, we know that they exist; their velocity has been actually measured at times and found to attain a maximum of 3½ knots, and it is probable that under certain conditions it may considerably exceed even that amount; but we do not know what causes them, and (which is the all important practical consideration) the navigator can, with our present knowledge, never foresee when he will encounter them, so that he may make due allowance for their effect upon his vessel.

The combination of these three factors—that is, the necessity of traversing long courses which at their end approach the shores closely, and of doing so in fog and with the vessel subject to the action of currents whose strength and direction are unknown—constitutes the problem which must be solved for safety of navigation on the Pacific coast. Indeed, considering the large number of strandings on record, it is surprising that the loss in lives and property has been so small.

METHOD OF COASTWISE NAVIGATION.

Vessels bound from Seattle to San Francisco steer one course from Umatilla Reef to Cape Mendocino. This distance is 464 miles, which, for a vessel making 12 knots, requires 39 hours to traverse. During those 39 hours the progress of the vessel will be affected by the prevailing currents. It has already been stated that actual measurements of the currents have given velocities up to 3½ knots. Such velocities are uncommon, and can not be accepted as indicative of what the vessel, during those 39 hours, would encounter. It is, however, fair to assume that the vessel actually may be affected by currents varying from 0 to 2 knots, and that their total effect upon the vessel would be to place her a distance of 30 miles ahead of or behind her position as fixed by dead reckoning. (See fig. 5.)

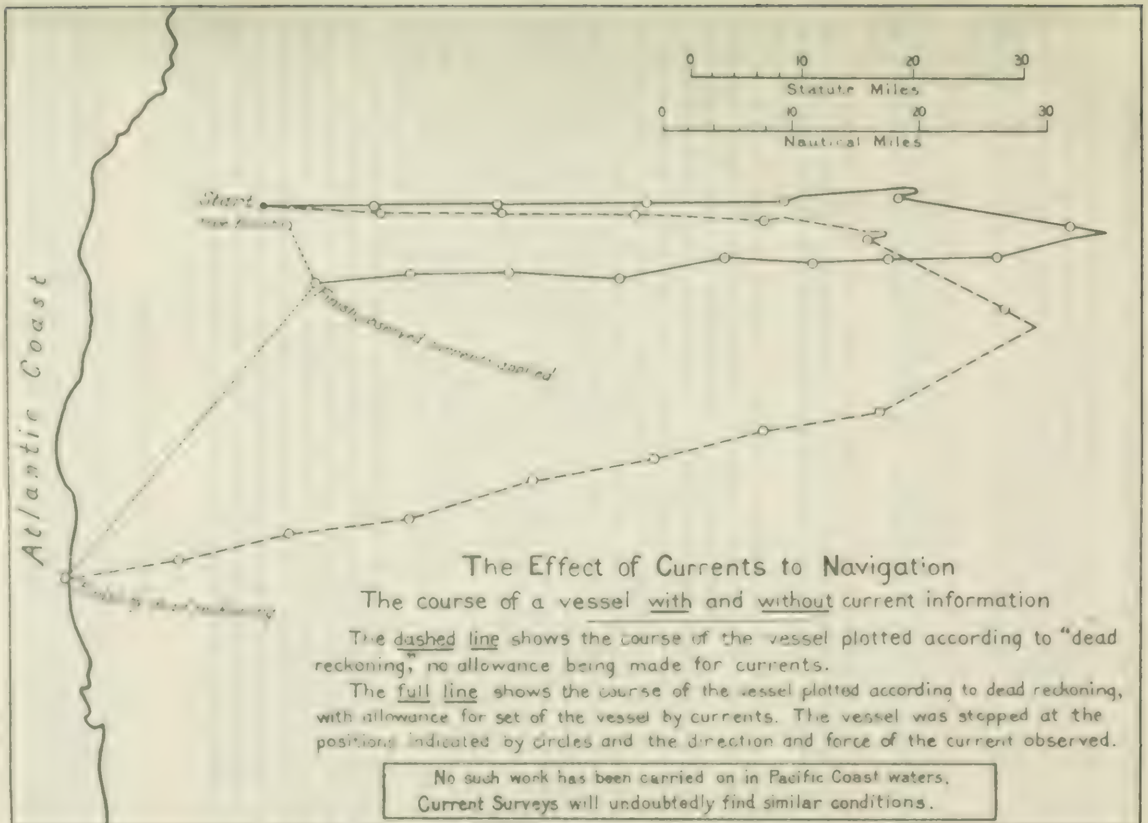
The same principles apply to every track which the vessel must traverse; the amount of current effect (within the limits of its probable velocity) being measured by the time required for the vessel to travel from point to point.

It therefore becomes essential that the navigator have some means of fixing his vessel's position as it nears each important turning point or danger. In clear weather, when the land can be seen, this can readily be done by referring to the ship's position to known points on shore. At any time, however, when the landmarks can not be seen, the problem becomes more difficult. The only method then left is to locate the vessel by means of soundings.

In a general way, it may be said that the topographic features which one sees from a coasting vessel following any shore are reproduced in modified form in the waters about him. If the shore and the country behind it are rugged and mountainous, the chart of the waters adjacent will generally show great irregularities of depth, while if the land is flat and featureless the waters will ordinarily have a uniformly flat or gradually sloping bottom.

Advantage may be taken of these differences in depth to locate a ship's position. A series of soundings is taken, spaced at any convenient interval. These are plotted, to the scale of the chart, on a piece of transparent paper which is placed on the chart and moved about, keeping the line of soundings parallel to the ship's track as laid down on the chart, until the soundings taken agree with the charted depths. If a sufficient number of soundings in irregular depths is taken, this method will fix a ship's position fairly well. If the depths are regular, sloping uniformly from the shore to deep water, the method will not work so well, but even in that case the soundings will fix the approximate distance of the vessel from the shore.

A modification of the above method is in common use on the Pacific coast. On the chart various depth contours are shown by dotted lines. The navigator, by a study of his chart, decides what is the least depth that it is safe for him to enter in approaching any turning point or danger. As he approaches the point he feels his way cautiously in toward the beach, sounding as he goes, until he reaches the chosen depth. He then, by means of his lead, follows that contour, hauling offshore when the depth decreases and inshore when it deepens. The direction which he must steer to keep in any chosen depth quickly indicates the position of his vessel. As fog signals are placed off most of the important turning points on the coast, the navigator, by following the proper depth contour, can feel his way to within sound of the fog signal, from which his course can be shaped for the next point.



The Effect of Currents to Navigation

The course of a vessel with and without current information

The dashed line shows the course of the vessel plotted according to "dead reckoning," no allowance being made for currents.

The full line shows the course of the vessel plotted according to dead reckoning, with allowance for set of the vessel by currents. The vessel was stopped at the positions indicated by circles and the direction and force of the current observed.

No such work has been carried on in Pacific Coast waters.
Current Surveys will undoubtedly find similar conditions.

DIFFICULTIES OF ROUNDING CAPES MENDOCINO, BLANCO, ETC.

An instance of the application of this method will be seen in the accompanying illustration (see fig. 6), which shows a section of the coast in the vicinity of Cape Mendocino. Vessels approaching the cape from northward must avoid Blunts Reef, the dangerous area of rocks and shoals off the cape, and at the same time must pass within sound of the fog signal on Blunts Reef light vessel, in order that from it they may shape their course for Point Arena, 97 miles beyond.

In order to accomplish this, when about off the entrance to Humboldt Bay, they feel their way in to a depth of 30 fathoms and then follow the 30-fathom curve, which is almost a straight line, leading clear of all danger but within easy hearing distance of the fog signal on the light vessel.

The importance of having complete and detailed surveys now becomes obvious. In order that it may be possible for the mariner to utilize the method of sounding for fixing his position, the chart must show, in detail, the correct depths at every place where it is possible for soundings to be taken.

By means of improved devices it is possible for vessels, without stopping, to sound in any depth up to about 100 fathoms (600 feet). Therefore, the charts, to be complete, should show the depths of all waters out to and beyond the 100-fathom curve.

This the charts do not show at present. As will be seen later, there are some regions where no surveys whatever have been made, and others where, due to incomplete surveys, the information shown on the charts is so inadequate as to be actually misleading.

It is considered an essential part of the duty of every maritime nation to furnish mariners with such data as will enable them to navigate the waters under its jurisdiction with the maximum possible degree of safety. The first essential of such data is complete and accurate charts. Yet, it must be confessed that after 70 years of navigation on this coast, the best charts available for our mariners are still so incomplete that a reasonable degree of safety of lives and property is assured only after those navigators have learned to supplement the information shown on the charts by additional essential knowledge gained from years of personal experience in those waters. The fact that disasters to passenger-carrying vessels do not occur oftener than they do is not due to accurate charts based on complete surveys but rather to the knowledge, skill, and vigilance of the men in command.

A case in point is shown in the accompanying illustration. (See fig. 7.) Cape Blanco is one of the important turning points on the coast. Every vessel plying between the Columbia River and San Francisco must safely round this cape. Yet, its northern approaches are absolutely unsurveyed; the best chart available is entirely devoid of information to assist the anxious navigator who, in thick weather, must sound his way around it. Local navigators have learned, through years of experience, that it is unsafe, in passing the cape, to permit the vessel to get in depths of less than about 60 fathoms. But what about the stranger who, lacking this intimate local knowledge and supplied with a chart which tells him nothing, meets disaster with its attendant loss of lives and property?

WRECK OF STEAMER "BEAR."

A typical example of what may happen as a result of incomplete charts and lack of current data is furnished by the case of the steamer *Bear* which, in June, 1916, stranded on the coast about 2 miles north of Cape Mendocino, with a loss of six lives and a vessel which, to-day, would be worth over $1,000,000. The details of this tragedy can readily be followed by means of the accompanying illustration. (See fig. 8.)

The *Bear* was southbound in thick weather. Since passing Cape Blanco, 10 hours before, they had not been able to locate their position. For 10 hours they had been subject to the action of currents of unknown direction and velocity. So the master of the vessel, when his reckoning put him about 15 miles northward of Cape Mendocino, began to take soundings to locate his position and felt his way to the light vessel, using the method that has already been described.

When they began sounding they were in deep water. They let out 1,200 feet of sounding wire without reaching bottom, which meant that they were in depths of over 100 fathoms (600 feet), or, according to the chart, somewhere outside the 100-fathom curve. They took a number of such soundings—no bottom at 100 fathoms. Then they got bottom, about 80 fathoms. They felt their way along, sounding as they went, getting bottom in depths which shoaled gradually from 80 to 34 fathoms. In other words, according to the chart they were always outside their danger line, the 30-fathom curve.

Then the next sounding reported again gave deep water—80 fathoms—and after that no bottom at 100 fathoms. According to the chart there was only one place where such a series of soundings could have been obtained. The vessel must have crossed the shoal plateau, which extends westward from Cape Mendocino, and entered the deep submarine valley which makes in toward the beach about 3 miles southwestward from the cape. (See fig. 6.)

In other words, the vessel must safely have passed the dangerous reefs off Cape Mendocino. The commander assumed that such was the case and changed his course for Point Arena. About an hour later the vessel stranded near the mouth of the Bear River, 2 miles northward of the cape. Instead of following, approximately, the track shown on the chart in black, it had actually followed the one shown in red. (See fig. 8.)

There is a disaster which cost six lives and a vessel valued at $1,000,000, which occurred as a direct result of the failure of the chart to supply the navigator with information essential to the safety of his passengers, his ship, and himself. (See fig. 9.) It is true that the official investigation of the disaster proved that the officers in charge had been guilty of what might be call contributory negligence, and that had it not been for such negligence the disaster might have been prevented.

INADEQUACY OF PRESENT CHARTS AND SURVEYS.

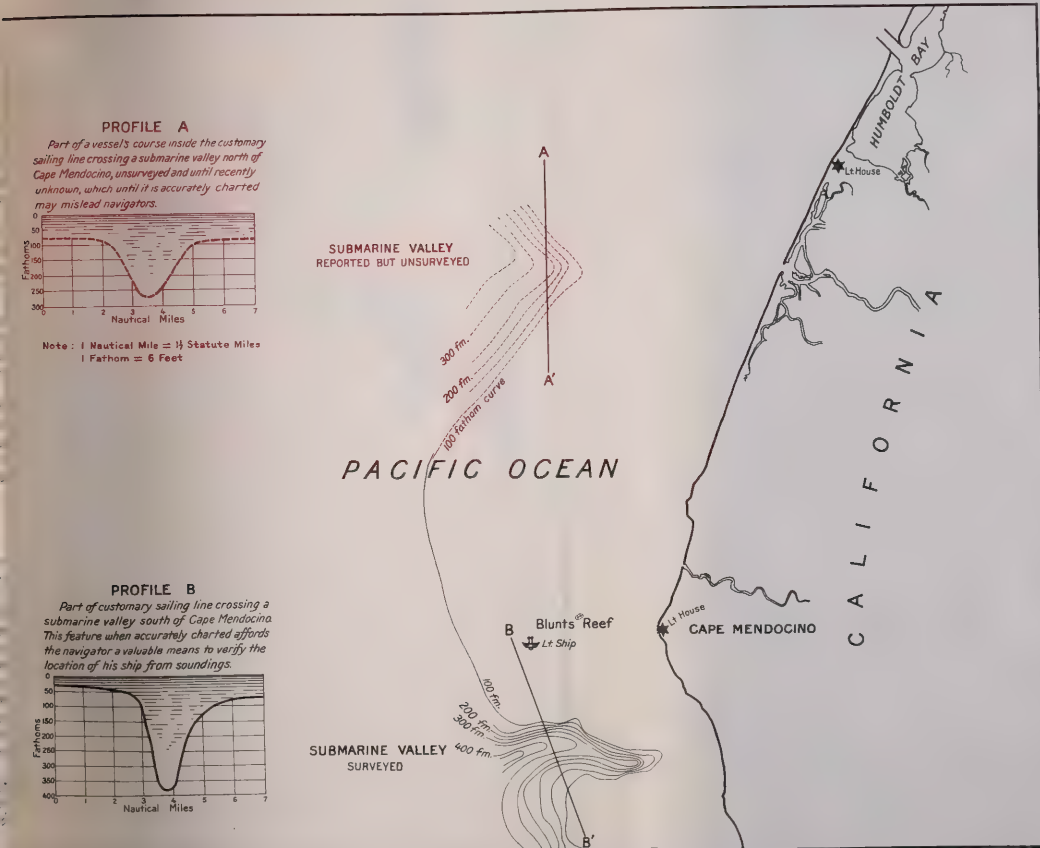
No fault on the part of the officer, however, can condone the greater fault of the chart, which almost daily jeopardizes life and property, as it did in the case of the *Bear*, by its failure to furnish adequate facilities for safeguarding navigation.

The best charts and other necessary data available failed in two ways. (See fig. 7.)

1. It failed to tell the navigator, as it should have been able to do, that there was a current running to the northward strong enough to set the vessel, in 10 hours, a distance of 14 miles from its supposed position. It will be shown later how this might have been done.

2. It compelled him to navigate by means of a chart so imperfect as to be actually misleading. This whole disaster hinges on the fact that the soundings, from being shoal, suddenly deepened to over 100 fathoms, and that according to the chart there is no place north of the cape where such depths exist. But there is good reason to believe that they do exist. Reports have been received from navigators recently that they have found in this vicinity just such depths as were indicated by the soundings taken by the *Bear*.

In 1907, a pamphlet, written by Captain P. A. Doran, was published by the San Francisco & Portland Steamship Co. It was practically a private coast pilot, published by that company for the guidance of its navigators because the charts did not furnish adequate information.



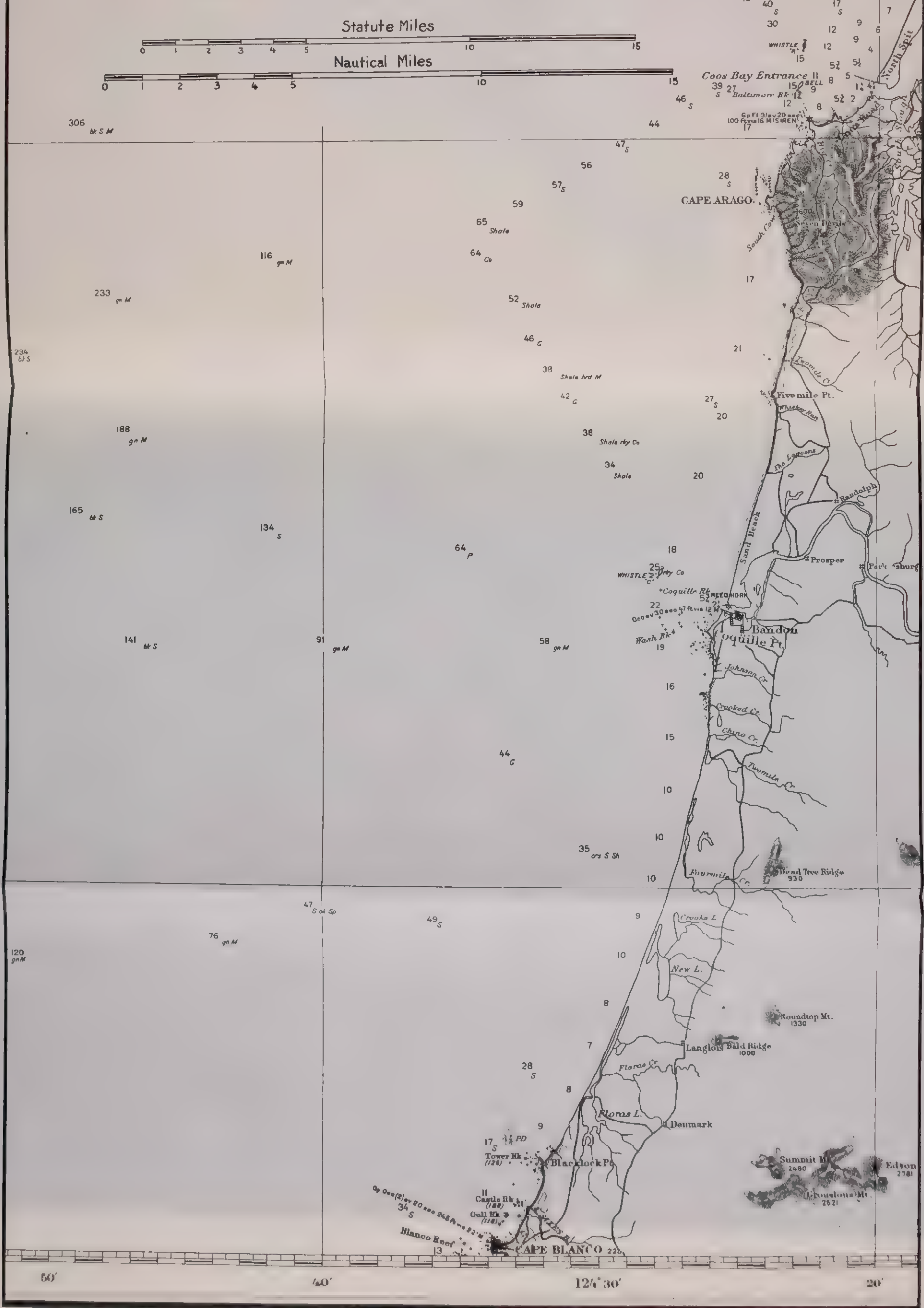
ubmarine Valleys, Pacific Coast – their relation to Navigation.

A TYPICAL SECTION OF A PACIFIC COAST CHART

On account of lack of surveys the soundings are few and widely separated. The navigator instead of being informed as to the ocean depth at least every mile, will, in many places, sail over a distance of ten miles of unknown depth.

SOUNDINGS IN FATHOMS
1 fathom = 6 feet

Abbreviations near sounding figures indicate character of bottom, thus: M = mud, S = sand, G = gravel, Sh = shells, P = pebbles, Sp = specks, Co = coral, bk = black, gn = green, hrd = hard, crs = coarse rky = rocky.



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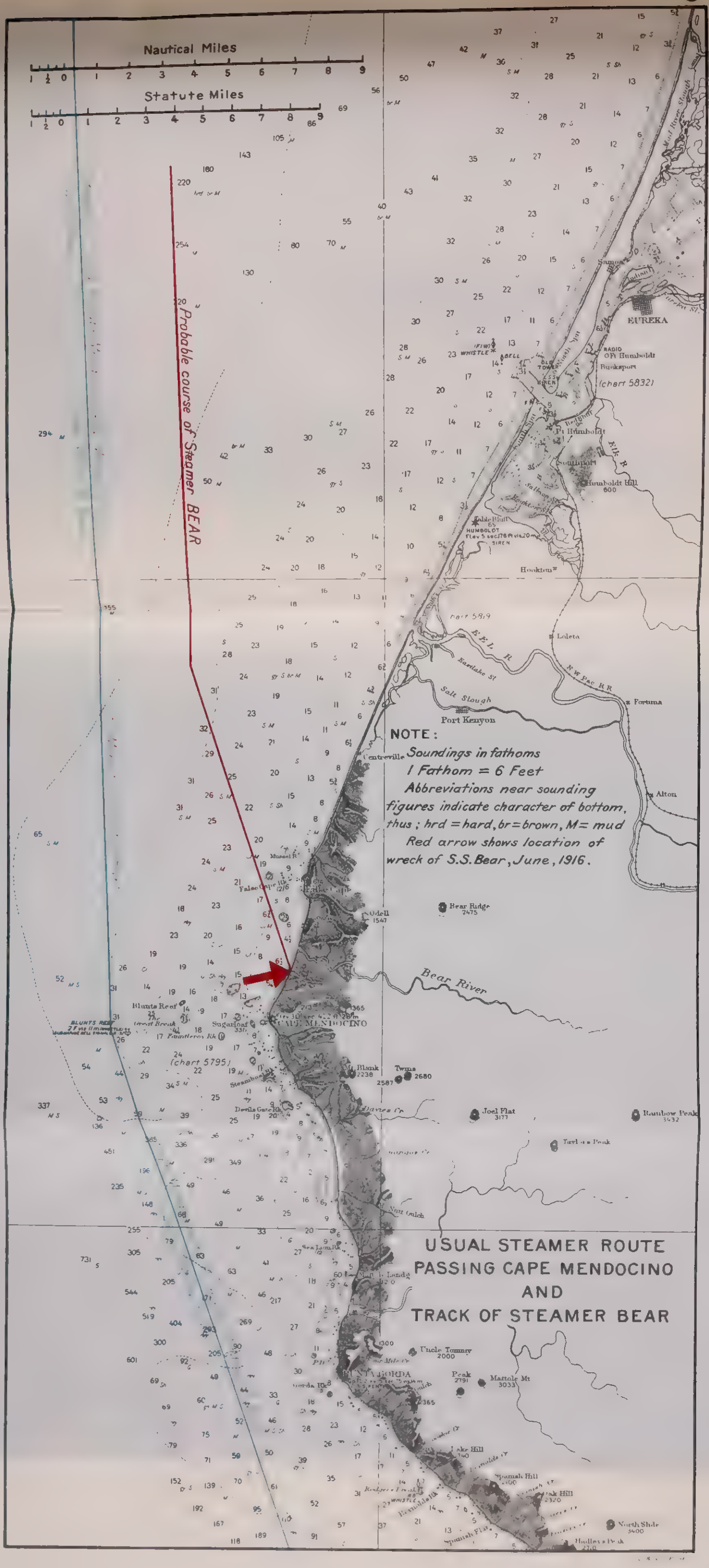

USUAL STEAMER ROUTE
PASSING CAPE MENDOCINO
AND
TRACK OF STEAMER BEAR
NOTE:
Soundings in fathoms
1 Fathom = 6 Feet
Abbreviations near sounding figures indicate character of bottom, thus; hrd = hard, br = brown, M = mud
Red arrow shows location of wreck of S.S. Bear, June, 1916.
Nautical Miles
Statute Miles
Probable course of Steamer BEAR
EUREKA
(chart 5832)
(chart 5795)
Elk R.
Humboldt Hill
Hookton
Loleta
EEL R.
Salt Slough
Port Kenyon
Fortuna
Alton
Centreville
Bear Ridge
Odell
Bear River
CAPE MENDOCINO
Sugarloaf
Blunts Reef
Blank
Twins
Joel Flat
Rainbow Peak
Devils Gate Rk
Uncle Tommy
Peak
Mattole Mt
Lake Hill
Spanish Hill
North Slide

9

With regard to the Cape Mendocino region, Captain Doran says, after relating in detail personal experiences which led to his conclusion:

Evidently there is a submarine valley, which reaches close up to the 30-fathom line somewhere between False Cape Rock and Blunts Reef. This valley was possibly mistaken for the deep water south of the cape by the Norwegian steamer *Tricolor* when she ran ashore and became a total loss about a mile north of Cape Mendocino during a dense fog in June, 1905.

Captain N. E. Cousins is another master who affirms the existence of this submarine valley. Captain Cousins is one of the ablest masters on the coast; he will be remembered as the man who, when his vessel, the *Congress*, burned off Coos Bay in the summer of 1916, saved every one of the 450 or 500 lives aboard her without a single accident. Captain Cousins has written in a letter describing safe methods of navigation in this vicinity:

* * * In following the 30-fathom curve you will lose bottom before you get to Cape Mendocino, as there is a submarine valley, but keep your lead going and you will soon pick up bottom again. Continue sounding until you lose bottom the second time; then you have passed Mendocino.

As a result of this wreck and the interest which it aroused, the charts have been "corrected" from such reports by adding a few soundings, uncertain as to position, and which do little more than emphasize the fact that the chart is incomplete and must be used with caution. Lacking the facilities for making proper surveys, that is all that can be done. But it is quite time for the public to awake to the fact that there is a more efficient method of correcting charts than by merely placing on them data obtained as a result of wrecks. (See figs. 10, 11, 12, 13, and 14.)

CHAPTER III.—REMEDY.

COMPLETE SURVEYS AND STUDY OF CURRENTS NEEDED.

The problem of properly safeguarding navigation is twofold. It consists in making complete surveys of the entire coast and in making a careful study of the currents, as a result of which their action can be foretold.

TIME REQUIRED TO COMPLETE FIRST SURVEY.

The task of making the necessary surveys along the coast is not altogether a large one. It is estimated that an able seagoing surveying ship could complete it in 20 years, including soundings along the entire coast out to the 1,000-fathom curve. But the public would by no means have to wait 20 years before deriving benefit from these surveys. The most important work, that in the vicinity of Cape Blanco or Cape Mendocino, would be undertaken first, and within a year after the vessel was made available the public would begin to reap the benefit in the form of greater security of lives and property

COST OF NEW VESSEL AND OPERATION FOR 20 YEARS.

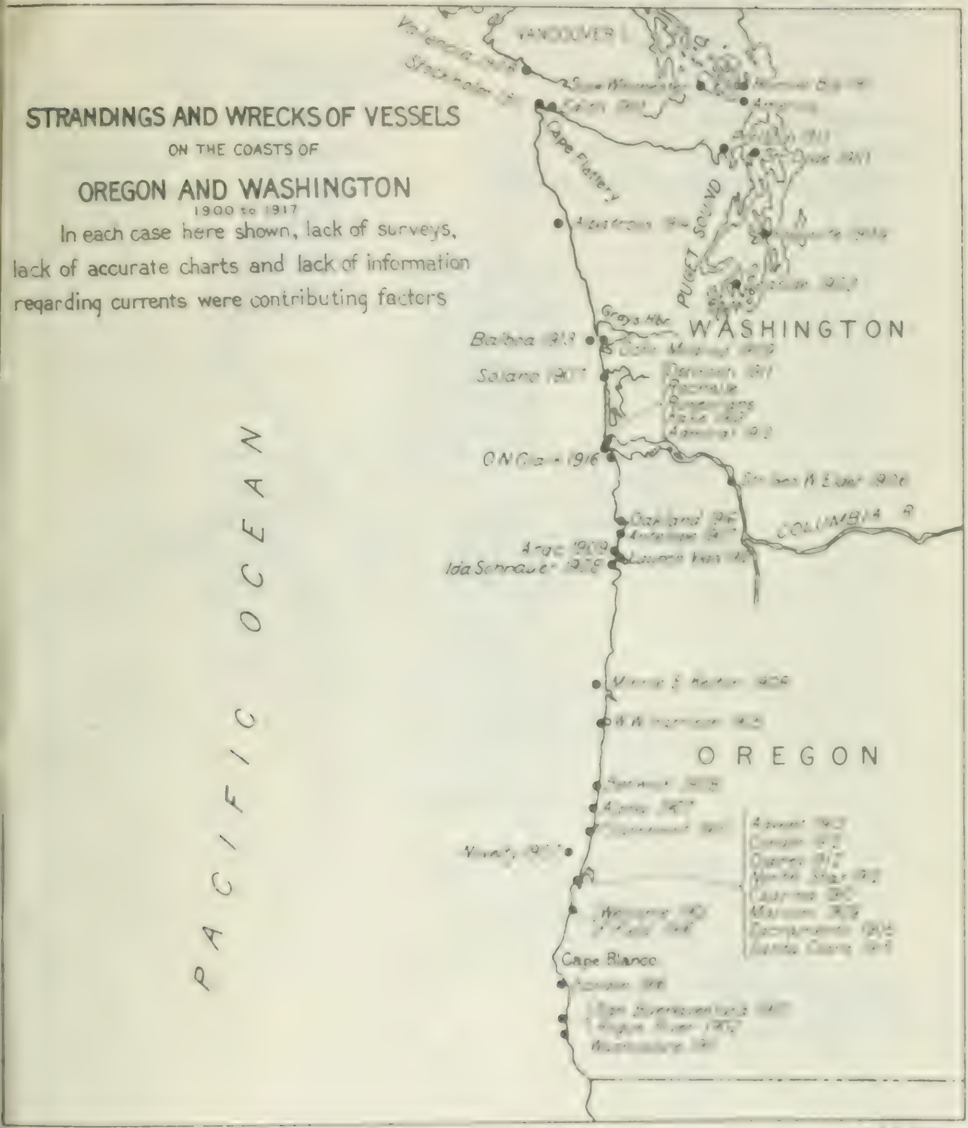
Nor would the cost of the undertaking be large. The necessary vessel, even in these days of high costs of shipbuilding, would cost only about $400,000. Her total annual cost of operation would not exceed $95,000, making the total cost for the vessel and 20 years' operation $2,300,000. This amount is far less than the loss resulting from the stranding of vessels on this coast in 1917 alone. (See fig. 1.)

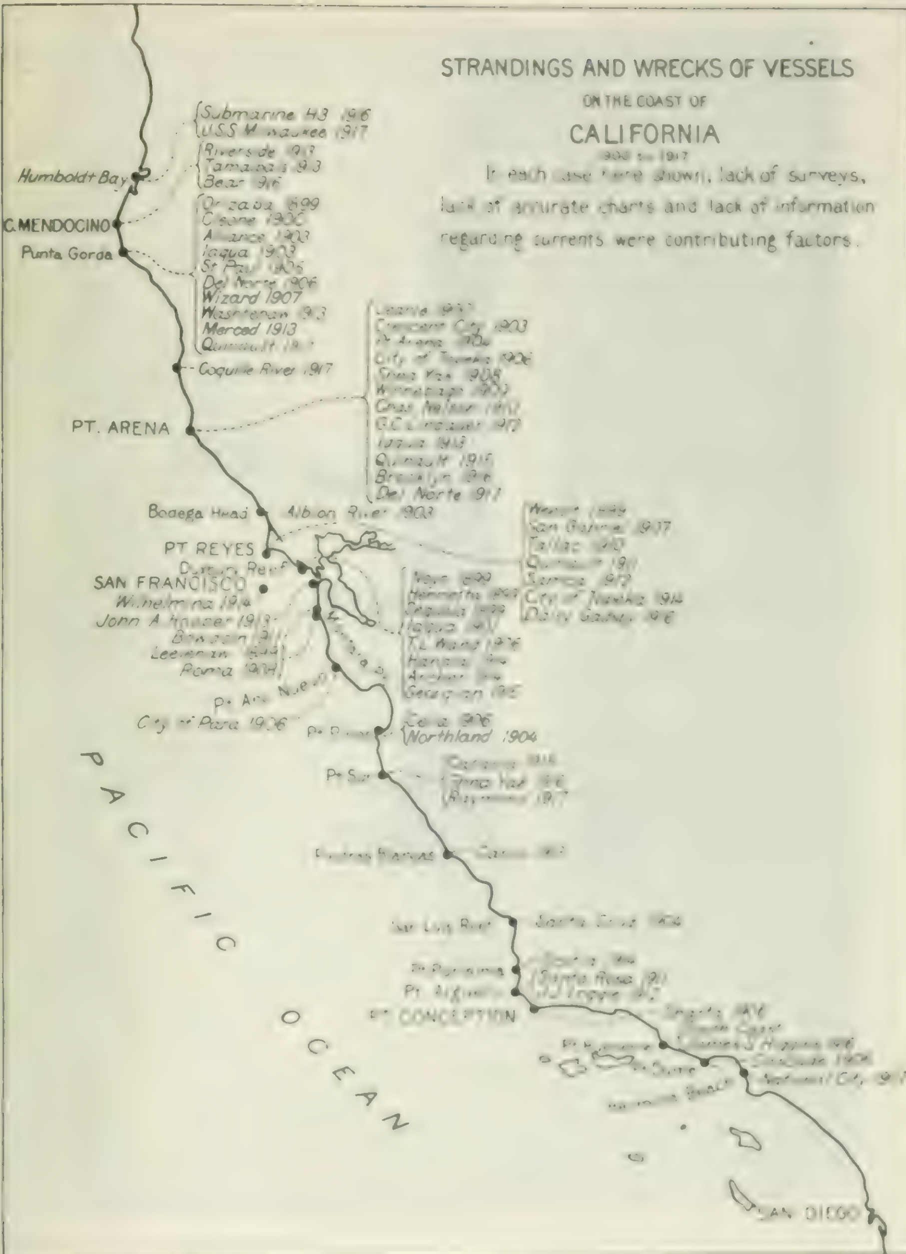
LIMITS OF SURVEYS.

It has been stated that the surveys should be carried out to the 1,000-fathom curve. The amount of work thereby entailed may seem excessive, when one remembers that vessels as a rule do not sound in depths of over 100 fathoms. There are, however, excellent reasons for carrying the surveys well beyond the limits of navigational soundings.

Only small portions of the regular coastwise steamer track lie within the region between the shore and the 100-fathom curve. These portions are in the area adjacent to the various points, and beyond these comparatively limited areas the track leads over depths greater than 100 fathoms. But there is every reason to believe that in these areas of deep water there exist shoaler banks. It would be most unreasonable to assume that the irregularities of depth, which, as we have already seen, are characteristic of this coast, cease abruptly at the 100-fathom curve. Indeed, such data as are at present available already indicate the existence of great irregularities of depth in these offshore waters.

It is important that such banks as exist be correctly charted, for if the steamer track crosses them, they afford a valuable means of verifying a vessel's position. A case in point is Heceta Bank, off the coast of Oregon, about 60 miles northward of Cape Blanco and 250 miles southward of Umatilla Reef Light Vessel, the point of departure for vessels bound southward from the Strait of Juan de Fuca.


STRANDINGS AND WRECKS OF VESSELS
ON THE COASTS OF
OREGON AND WASHINGTON
1900 to 1917
In each case here shown, lack of surveys, lack of accurate charts and lack of information regarding currents were contributing factors
VANCOUVER I.
Valencia 1906
Cape Flattery
PUGET SOUND
Grays Hbr.
WASHINGTON
Balboa 1913
Solano 1907
COLUMBIA R.
Argo 1909
Ida Schnauer 1908
OREGON
Cape Blanco
PACIFIC OCEAN


STRANDINGS AND WRECKS OF VESSELS
ON THE COAST OF
CALIFORNIA
Submarine H3 1916
U.S.S. Milwaukee 1917
Humboldt Bay
C. MENDOCINO
Punta Gorda
Wizard 1907
Merced 1913
PT. ARENA
Bodega Head
PT REYES
SAN FRANCISCO
Northland 1904
PACIFIC OCEAN
SAN DIEGO

13

14

During the entire run of 250 miles the track, so far as known, leads through deep water, and hence, in thick weather, it is impossible to verify the position by sounding. The vessel may have either gained or lost 20 to 30 miles, and it is important to locate its position before attempting to approach Cape Blanco. Therefore, as they approach Heceta Bank they begin taking deep soundings, no bottom at 100 fathoms, and continue until the lead finds bottom showing that they have reached the bank. Having done this, the uncertainty to which they will be subject on approaching Cape Blanco is limited to that accumulated in the 60-mile run between the bank and the cape.

Every such bank should be located and charted, for the greater the number of such shoal areas available the safer will navigation become. If the areas where fixes can be obtained are too far apart, the vessel may be set so far from her supposed position that the navigators will be deceived by the soundings obtained and disaster may result. A particularly sad case, which will remain fresh in the minds of Pacific coast residents for many years, was of this sort.

WRECK OF THE "VALENCIA."

This was the steamer *Valencia* (see fig. 15), which, on January 22, 1906, stranded and became a total loss on the coast of Vancouver Island, with the loss of 134 out of the 169 lives on board.

As the commanding officer was lost, it has never been possible to ascertain the complete history of the events which culminated in this catastrophe. From the second officer and survivors among the crew, however, enough was learned to indicate in a general way what had happened.

The steamer *Valencia* left San Francisco for Seattle on January 20, passing Cape Mendocino about 18 hours later. This apparently was the last land clearly seen. About 12 hours after passing Cape Mendocino the wind, which had been northerly, became a strong breeze from the southeast, which continued during the remainder of the voyage.

About 3 hours before the stranding the master, apparently believing that he was from 35 to 40 miles south of Umatilla Reef Light Vessel, began to take soundings to locate his position, and these sounding were continued at intervals until the vessel struck. As a matter of fact, however, at the time the soundings were begun the vessel, instead of being where the master supposed her, was actually about abreast the light vessel; in other words, some 35 or 40 miles ahead of her supposed position.

In its official report the Steamboat-Inspection Service states:

> The loss of the *Valencia* appears to have been due to insufficient soundings and failure to interpret correctly the soundings taken and to the absence of adequate aids to navigation at the entrance to the Strait of Juan de Fuca and on the southwestern coast of Vancouver Island.

In other words the vessel through the lack of sufficiently frequent determinations of position had gotten so far ahead of her supposed position that the master was completely deceived by his soundings when he did take them.

As having a bearing on the general subject of coastwise navigation on the Pacific coast of the United States the following extracts are quoted from the recommendations by the commission on the *Valencia* disaster, [illegible]:

> The dangers of this entrance [Strait of Juan de Fuca] are all out of proportion to the present lighthouse and fog-signal equipment. The conditions of coast and weather are wholly different from those prevailing on the Atlantic coast. The coast itself is bluff and rocky; deep-sea soundings may be obtained close inshore and are therefore of little value in determining a ship's position; and throughout at least one-half the year fogs and haze prevail in this vicinity, and these fogs lie in such peculiar formations that, as was the case with the *Valencia*, vessels offshore may be in a fog or haze while the shore lights are in clear weather and their keepers have no knowledge that the fog prevails offshore, and

hence do not operate their fog signals. It is also well known, by experiments of the Lighthouse Board made on the Atlantic coast, that the radiation of sound from fog signals is extremely erratic and that such signals can not be relied upon, nor is it even possible to determine decisively the causes of these aberations. The commission itself, while cruising off Cape Flattery Light in comparatively clear weather, at a distance westerly of a mile and a quarter, saw repeatedly the steam issue from the fog signal at the light as it was blowing, but could not hear the signal.

This entrance to the strait is of somewhat peculiar geographic nature, as will be observed from the chart in this report. The west shore of Vancouver Island lies almost directly across the inward course of steamers coming from the Orient and especially of those coming from down the coast. In the case of steamers coming from down the coast, they must proceed up the coast headed directly toward Vancouver Island, and, upon reaching Cape Flattery, must then turn sharply to the eastward and find the entrance to the strait, which is about 12 miles wide, and if this turn is not made at the proper time, as was the case with the *Valencia*, the vessel must inevitably go ashore on the Vancouver coast.

Evidence covering a period from 1855 to 1890, exhibited to the commission, showed wrecks of 35 vessels in as many years on the west shore of Vancouver Island in this vicinity, all of which vessels had been trying to make this entrance to the strait; and since 1890 at least as large an additional proportion of vessels has gone ashore there, so it is safe to say that at least an average of one wreck a year occurs in this locality, and probably during the time these records have been kept in the last 50 years between 500 and 700 lives have been lost there, to say nothing of millions of dollars' worth of property. Cape Flattery, therefore, and its immediate vicinity is the key or turning point of the entrance to the strait and is of the utmost importance to navigators.

There exist also currents in this locality, and as far down as San Francisco, which vary in force and direction with the varying seasons of the year, and also, within a given season, vary with the different conditions of the wind, and are further complicated at the mouth of the strait by the strong tides there, and these currents are at present very little understood, even by those who navigate them constantly. The fact that the *Valencia* was off her course was primarily due to the existence of such a northward current.

There should be made and published a careful series of observations of the currents along this coast during at least a period of one year and covering all possible conditions of season, weather, and winds, to ascertain, if possible, whether any definite rules can be established for the guidance of mariners as to the operations of these currents. This work could be taken up directly in connection with the work of the Coast and Geodetic Survey and only a comparatively small appropriation would be necessary to enable the survey to carry it out.

Steamship owners should require their masters and navigating officers to procure and have on board the best and most modern charts and all the publications of Government bureaus bearing upon questions of navigation, currents, winds, tides, etc., and should see that the navigating officers use and become familiar with all these sources of information.

DEFINITE KNOWLEDGE OF CURRENTS NEEDED.

The need of accurate and detailed knowledge of the currents is quite as imperative as the need for additional surveys. It is the currents which keep the master on the bridge day and night throughout the duration of every foggy voyage. Compasses can be so corrected, or their errors so accurately ascertained, that the courses steered will be known to be approximately exact. Logs can be so standardized that the distance which a vessel travels through the water in any given time can be determined with approximate accuracy. But when the waters themselves are in motion at an unknown speed and direction the compass and log, no matter how accurate, can not be trusted. If, however, the action of the currents can in any way be predicted, or if the navigator can be informed from day to day of the character of the currents existing, a great advantage will have been made in the problem of safeguarding lives and property.

Before any accurate predictions of the currents can be made, the data available at present must be supplemented by a large amount of additional information, gathered through some years of observations, consisting of measurements of the velocity and direction of the currents, together with a record of the conditions under which they occur.

There are three ways in which such data can be collected:

1. By observations on the various light vessels anchored along the coast.
2. By special observations taken by the surveying vessels in the course of their survey.
3. By reports from merchant vessels, giving the effect of the currents upon their vessels.

Sufficient has already been told regarding the character of these currents to indicate in a general way the difficulties which will probably be encountered in their study. Probably the greatest of these difficulties lies in what may be termed the "accidental" character of the generating forces. The tides can be predicted years in advance, and when they actually occur will differ from the predictions only by insignificant amounts, due to temporary local causes. But the factors which combine to cause the tides are known and constant, whereas the factors which cause the currents (if the theory that they are the result of meteorological conditions over a wide area is correct) are never twice the same. (See figs. 5 and 8.)

CURRENT OBSERVATIONS REQUIRED.

The problem, although difficult, is by no means beyond solution, however. It may never be possible to publish tables predicting the character of the currents that will be encountered, such as are published by the Coast and Geodetic Survey in the tide tables for other waters of the United States, but it is probable that another method can be substituted which will serve quite as well.

This method is as follows:

The portion of the coast where a knowledge of the currents is of greatest importance is that from the Strait of Juan de Fuca to San Francisco Bay. There are five places on this stretch of coast where light vessels are maintained the year round: Off San Francisco Bay; Cape Mendocino, on the northern California coast; Columbia River; Umatilla Reef, off the coast of Washington; and Swiftsure Bank, at the entrance to the Strait of Juan de Fuca.

Current observations, extending continuously over a period of from three to five years, should be taken at each of these light vessels. These observations should include measurements of the direction and velocity of the currents, direction and velocity of the wind, direction and character of the swell, etc. In other words, there should be obtained complete data of all currents, together with the conditions under which they occur. In this way it may be possible to establish a definite relation between the currents and certain other meteorological conditions which can be observed by the navigator and which will warn him that currents will probably be encountered. For instance, some navigators believe that currents which occur with no unfavorable local weather conditions to account for them are caused by northwesterly or southwesterly winds so distant that they do not reach the track of coastwise shipping. The currents set in motion by these storms flow in the direction of the winds—that is, to the northeastward or southeastward—until they strike shoal water, when they are deflected to the north or south, following the general trend of the coast. But these storms also cause a swell, which will far outdistance the winds themselves. Everyone familiar with the Pacific coast knows the heavy ground swell which sometimes comes rolling in during periods of calm weather.

It is possible that observations may prove that currents and swell travel together and that when the navigator encounters such a swell he must guard against a current from the same direction. Some navigators at present assert that such a relationship actually exists.

Such considerations as these, however, do not exhaust the possibilities. It seems feasible to work out a more definite and practical method than the one already indicated.

While the observations are being taken at the light vessels, all possible data should be obtained at intermediate points. Such data may be the result of measurements by surveying vessels or derived from reports by navigators of the currents encountered at various localities during each voyage. The currents at the intermediate points would then be compared with those at the light vessels, the relations between them established, and tables giving these relations published. Such tables might show, for instance, that when the current at Blunts Reef light vessel is running northwest at a rate of 1 knot, 50 miles north of Blunts Reef it would be running north at a rate of 1½ knots.

WARNINGS BY RADIO FROM LIGHT VESSELS.

Meanwhile, light vessels are being equipped with radio as rapidly as funds will permit, and it is reasonable to assume that by the time the above studies have been completed every light vessel on the Pacific coast will be so equipped.

The plan will then be ready to be put in operation. The velocity and direction of the current at the light vessel will be measured once an hour, or once every four hours, and the information sent out broadcast by radio. The navigator, receiving these reports, can consult his tables and ascertain what is the corresponding current in his vicinity, and thus have constant warning of any unusual conditions prevailing as he approaches any of the important turning points.

Such, in its simplest form, is the plan which has recently been suggested. It would be absurd to imply that the actual problem is as simple as here indicated. There are many complications and difficulties involved. Some of them can be overcome; others may prove insurmountable, resulting in limitations to the practical application of the plan.

MASTERS OF COASTWISE VESSELS CAN HELP.

The following are some of the difficulties which will at once suggest themselves to those familiar with local conditions:

1. It will be difficult to secure sufficient data from all parts of the extensive areas between adjacent light vessels. To overcome this difficulty, however, it is only necessary to secure the active cooperation of masters of the various coastwise vessels. And as these men are the ablest of their class, already keenly interested in the problem and aware of its importance, it seems certain that they will gladly do everything in their power to assist in its solution.

2. Light vessels may be so situated that conditions in their immediate vicinity will not afford a clear index of those existing at a distance. They may be outside the path of the current or in an eddy. This difficulty, however, is probably more apparent than real. Where a large amount of data is available upon which to base conclusions, it is by no means difficult to reconcile specific, individual cases which at first glance appear absolutely contradictory.

3. In some cases, adjacent light vessels are so far apart that local currents may exist between them, of which no indication is furnished at either vessel. For example, it is 347 miles from Blunts Reef to the Columbia River, a distance sufficient to afford ample opportunity for the production of local currents of considerable velocity. Or, an offshore current might flow in from the southwestward, striking the coast north of Blunts Reef and thence flowing northward, be deflected to the westward again by the projecting land at Cape Blanco, 144 miles north of Blunts Reef, without any indication being furnished at either light vessel.

The difficulties under this heading will probably prove the most serious ones encountered; how serious it is impossible to predict at this time. There is no doubt that observations off Cape Blanco would materially strengthen the proposed scheme, but there is no light vessel available and we have not a vessel of the Coast Survey service to secure the data required.

In summation, however, it may be said that, serious as some of these difficulties undoubtedly are, it is certain that sufficient results can be obtained to fully justify the efforts. Even if those results are limited to the prediction of the currents within 50, or even 25 miles of each light vessel, the safety of navigation will be materially increased. If the *Valencia* could have been informed, as she steamed northward, that there was a current flowing past Umatilla Reef light vessel at a speed of over 3 knots, she never would have been wrecked. It would not even have been necessary for the master to know accurately what current he was encountering 100 miles south of the light vessel; the one fact that such a current existed ahead of him would have been suf-

ficient. Common sense would have told him the rest; he would have been on his guard, and by an earlier use of his lead would have entered the strait in safety. The very least that this plan can do is to furnish such warnings, while it is probable that it can accomplish much more.

CONCLUSION.

Too much emphasis can not be laid on the fact that it is vitally necessary to begin these surveys and current studies at the earliest possible moment. It is not merely that the work has already been too long delayed—that for years lives and property have been needlessly jeopardized. It means even more than the ending of such present jeopardy.

This Nation is entering upon an era of maritime expansion. Our isolation has ended forever. The end of the present world conflict will see the merchant fleet which we are now building released from the restrictions imposed by our need for trans-Atlantic transport, sailing the Seven Seas in a struggle to regain the preeminence which was ours in the old days of the clipper ships, only to be destroyed by the upheaval of the Civil War.

In this maritime expansion the Pacific coast will have a full share. And with the coming of new ships there will come new commanders, men unfamiliar with the special conditions affecting navigation. It has already been stated that the present comparative immunity of shipping in places is due less to the facilities furnished by our surveys and charts than to the intimate local knowledge of conditions possessed by the present masters, who have gained it only by years of experience.

Strangers lacking this local knowledge must navigate by the chart, and unless the charts are perfected and the currents known, the inevitable result will be a marked increase in the number of disasters occurring, an increase out of all proportion to the increase in the number of vessels.

We have already waited too long; the Pacific coast has been woefully neglected, and years of work are required to complete the important task. It is vital for the safety of the traveling public, our commercial interests, and our Navy that there be no further delay in recognizing the needs and providing adequate facilities for pushing the work.